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Analysis of Single-Story Building by Etab

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Abstract- In civil engineering, structural analysis and structure design come before building construction. The resistance of the building to various loads must be examined. The way that various loads behave affects various structural parts, including beams, slabs, columns, shear walls, and footings. We need to design the members by observing their behavior. Analysis is therefore essential to a building's structural design. The analysis also aids in the design of a cost-effective and safe construction process for any given project. Extended Three-Dimensional Analysis of Building Systems is referred to as ETABS. Concrete structures, skyscrapers, low- and high-rise buildings, and portal frame structures are all frequently analyzed using ETABS. Summary of a few of the analysis methods that ETABS offers. P-Delta, linear static, modal, response-spectrum, time-history, linear buckling, and nonlinear analyses are among the sorts of analyses that are in turn building any kind of structure. This paper's case study primarily focuses on the structural behavior of single-story buildings with L-shaped layouts. The ETABS software models single-story R.C.C. framed buildings for study. ETABS characteristics include a strong graphical user interface along with unparalleled analytical, modeling, and design processes that are all connected via a shared database. The most comprehensive software package for building design and structural analysis is the new, cutting-edge ETABS. A wide range of materials can be designed with sophisticated and comprehensive capabilities using ETABS's unmatched 3D object-based modeling and visualization tools, lightning-fast linear and nonlinear analytical power, and perceptive graphic displays, reports, and schematic drawings that make it simple for users to interpret and comprehend analysis and design outcomes. In this project, the ETAB analyzes the single-story building to determine the details of the reinforcement, deflections, bending moments, and shear forces for the given single-story building. ETABS software has been utilized for the analysis and design of beams, columns, and slabs. M-20 and M-30 concrete as well as Fe-415 have been employed as building materials. Single-story building design and analysis are completed in compliance with IS-Code requirements. The IS 456-2000 standards were followed in the design of the single-story building's reinforcement and concrete to carry out the structural analysis and design without experiencing any kind of failure; 1. To use Indian Standard Codes to comprehend the fundamentals of construction; 2. To comprehend the limitations of the design for the structural elements of slabs, beams, and columns; 3. To create a detailed analysis and design of the structure's 3D model using the E-TABS software. Thus, in the present research work, the design and analysis of a single-story building were carried out by using ETAB software and successfully verified as per IS456:2000.

Keywords- Analysis, Design, grade of concrete, Grade of steel, poisons ratio, Bending moment, Shear force, reinforcement

I. INTRODUCTION

Designing a structure with strength, stability, and workability in mind is the goal of structural design. The structure's design must essentially meet three requirements, including Steadiness to stop the structure from toppling over, slipping, buckling, or any of the components when weight is applied; strength to withstand the stress placed on different structural components; Serviceability is the ability of a structure to perform satisfactorily when subjected to service load conditions. This approach provides sufficient stiffness and strength, as well as reinforcement to prevent deflection and vibration within acceptable bounds. Structural design presents a significant difficulty for civil engineers. The design needs to meet several requirements, such as serviceability, durability, and an affordable structure. But keeping these things in mind, when an engineer performs a design by hand, it becomes exceedingly challenging for them to meet all these needs at once. The project work highlights the distinction between the tools that future users will need to go through to meet their demands. built a residential building that ETABS is now designing with appropriate loading. The differences between the Software are easily discernible through manual computations [Chethan V R, et al, 2023]. The field of structural analysis studies how structures behave to forecast how real structures like buildings, bridges, and trusses will behave in terms of economy, elegance, serviceability, and durability. The task facing structural engineers is to ensure that a building's final design is serviceable for its intended use for the duration of its design lifetime while also pursuing the most accurate and cost-effective design possible. In addition to a solid understanding of the science behind structural engineering, current legal design codes, intuition, and sound judgment, structural planning and design call for both creativity and conceptual thinking. This study examines G+ 2 residential apartments located in Pipulpati More, Hooghly. ETABS and AutoCAD software is being used. Additionally, numerous work items are estimated, and a rate analysis is conducted using the most recent PWD schedule [Raja Saha, et al, 2017]. The field of structural analysis studies how structures behave to forecast how various structural components will react when loads are applied. Every structure will be subjected to one or more sets of loads; the several types of loads that are typically taken into consideration include wind, earthquake, dead, and living loads. Extended Three-Dimensional Analysis of Building System, or ETABS, is a software that is specifically used to study and design buildings. It incorporates all the primary analysis engines, including static, dynamic, linear, and non-linear ones. We are attempting to use ETABS for the analysis and design of a commercial building in our project, "Analysis and Design of Commercial Building using ETABS software." For this analysis, a G+3 story building is considered. Static analysis is used, and design is completed in accordance with IS 456:2000 specifications. Additionally, a manual design of the structural parts has been attempted. Auto CAD is used for drawing and detailing in accordance with SP 34. [José Ragy, et al, 2017]. The examination of a commercial building (G+1) in Hyderabad that is subject to seismic stresses is covered in this paper. Larger spans have more shear forces and bending moments, according to observations of the shear forces and bending moments of beams and columns [S. Abhishek, et al, 2018].

Determining a structure's behavior to forecast how various structural components will react to loading impacts is known as structural analysis. All structures are going to be subjected to loads, often multiple loads. Dead load, live load, seismic load, and wind load are some of the common loads that are considered. Analyze several loads, including dead load, live load, and seismic load, in our project using ETABS software. The project's primary goal is to get an adequate understanding of architectural design, analysis, and planning. An important and necessary ability for any engineer to have been practical knowledge. A fundamental understanding of both theoretical and practical knowledge of structural engineering is necessary for the study and design of multi-story buildings. In this project, we primarily use ETABS to analyze and design multi-story buildings, with a focus on (G+4) residential buildings. The design is completed in compliance with IS 456:2000 requirements, and the analysis is completed using static methods. AutoCAD software is used to create drawings of plans, elevations, sections, site plans, service plans, etc. [Azhar C K, et al, 2022].

II. RESEARCH OBJECTIVES

The present research work is an attempt to interpret the Bending moment, Shear force, and Percentage of Steel reinforcement in concrete Beams/ Columns/ Slabs to achieve the specified code limits in case of analysis and design. The overall goal of this research is to use ETABS software to construct a given structure and analyze variations in building analysis and design. The software ETABS was used for structural analysis and design. The following codes were utilized for design and analysis: IS:4566-2000 Code/ IS 13920:2016.

III. EXPERIMENTAL PROGRAM

In the present research work, the design and analysis of single-store building with L shape were carried out by using ETAB software in which Geometric and Material properties were highlighted as shown in Table 1-2. Furthermore, cross section and longitudinal cross section of Beam (300x400) as shown in Figure 1.

Table 1 Geometric Properties

Beam Label	Section Property	Length	Section Width	Section Depth	Distance to Top Rebar Centre
11	Beam	5 m	300 mm	400 mm	25 mm

Table 2 Material properties

Concrete Comp. Strength	Concrete Modulus	Longitudinal Rebar Yield	Shear Rebar Yield
20 MPa	22360.68 MPa	415 MPa	415 MPa

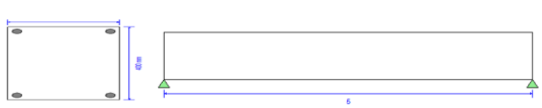

Figure 1 Cross section and Longitudinal section of Beam

From the design and analysis of Beam element type (Table 3), it's possible to interpret the following parameters such as factored forces and moments, design moments, design moments and flexural reinforcement for moment, shear force and reinforcement for shear, torsion and torsion reinforcement for torsion which is represented as in Table 4 to Table 8.

Table 3 Beam Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story1	B9	9	Beam	1.5(DL+LL)	4800	5000	1

Table 4 Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-39.6624	5.8383	36.6848	0.974

Table 5 Design Moments, Mu3 & Mt

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-39.6624	8.0133	0	-47.6757

Table 6 Design Moment and Flexural Reinforcement for Moment, Mu3 & Tu

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-47.6757		368	0	368	291
Bottom (-2 Axis)		0	184	0	0	184

Table 7 Shear Force and Reinforcement for Shear, Vu2 & Tu

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm^2/m
36.6848	44.7186	45	0	332.53

Table 8 Torsion Force and Torsion Reinforcement for Torsion, Tu & VU2

T_u kN-m	V_u kN	Core b_1 Mm	Core d_1 mm	Rebar A_{svt} /s mm^2/m
5.8383	36.6848	270	370	289.16

Similarly, the variation in Bending moment, shear force, and Torsion values was represented for beam length of 5m in Figure 2. Furthermore, the design and analysis of the lateral beam (300x400) mm were interpreted with a length of beam 4m (Figure 3). In which their geometric as well as material properties are represented in Table 9 and Table 10.

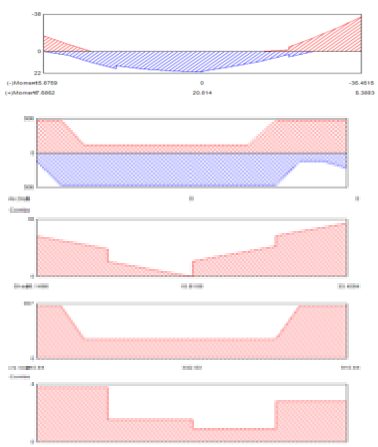

Figure 2 Bending moment/Shear force/Torsion diagram

Table 9 Geometric Properties

Beam Label	Section Property	Length	Section Width	Section Depth	Distance to Top Rebar Center
2	Beam	4 m	300 mm	400 mm	25 mm

Table 10 Material Properties

Concrete Comp. Strength	Concrete Modulus	Longitudinal Rebar Yield	Shear Rebar Yield
20 MPa	22360.68 MPa	415 MPa	415 MPa

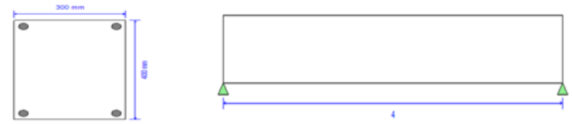

Figure 3 Cross section and Longitudinal section of Beam

From the design and analysis of Beam element type (Table 11), it's possible to interpret the following parameters such as factored forces and moments, design moments, design moments and flexural reinforcement for moment, shear force and reinforcement for shear, torsion and torsion reinforcement for torsion with a length of beam 4m which is represented as in Table 12 to Table 16.

Furthermore, the variation in Bending moment, shear force, and torsion values were represented in Figure 4.

Table 11 Beam Element Details Type: Ductile Frame (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story1	B2	2	Beam	1.5(DL+LL)	3800	4000	1

Table 12 Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-6.0434	3.26	23.3573	2.3677

Table 13 Design Moments, Mu3 & Mt

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-6.0434	4.4745	0	-10.5179

Table 14 Design Moment and Flexural Reinforcement for Moment, Mu3 & Tu

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-10.5179		291	0	75	291
Bottom (-2 Axis)		0	73	0	0	73

Table 15 Shear Force and Reinforcement for Shear, Vu2 & Tu

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
23.3573	41.0872	45	0	332.53

Table 16 Torsion Force and Torsion Reinforcement for Torsion, Tu & VU2

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
3.26	23.3573	270	370	0

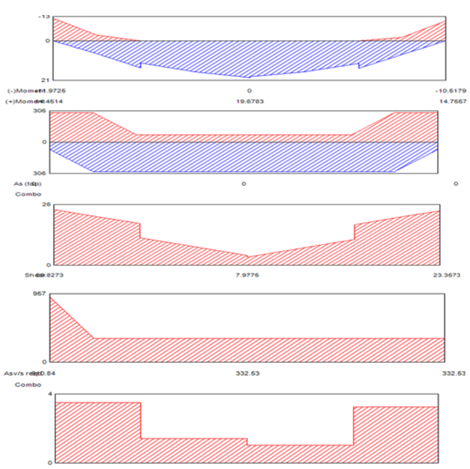

Figure 4 Bending moment

From the design and analysis of Column element type (Table 17-Table 19), it's possible to interpret the following parameters such as Longitudinal reinforcement design, design axial force and Biaxial moment, and shear force reinforcement which is represented as in Table 20 to Table 23.

Table 17 Column Element Details

Level	Element	Unique Name	Section ID	Length (mm)	LLRF
Story 1	C2	14	Column	3500	1

Table 18 Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
400	400	60	30

Table 19 Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
22360.68	20	1	415	415

Table 20 Longitudinal Reinforcement Design for Pu - Mu2 - Mu3 Interaction

Column End	Rebar Area mm²	Rebar %
Top	1280	0.8
Bottom	1280	0.8

Table 21 Design Axial Force & Biaxial Moment for Pu - Mu2 - Mu3 Interaction

Column End	Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Station Loc mm	Controlling Combo
	kN	kN-m	kN-m	mm	
Top	54.9017	19.9941	21.818	3100	1.5(DL+LL)
Bottom	73.4962	6.7569	9.0333	0	1.5(DL+LL)

Table 22 Shear Reinforcement for Major Shear, Vu2

Column End	Rebar A_{sv} /s mm²/m	Design V_{u2} kN	Station Loc mm	Controlling Combo
Top	443.37	5.2155	3100	1.5(DL+LL)
Bottom	443.37	5.2155	0	1.5(DL+LL)

Table 23 Shear Reinforcement for Minor Shear, Vu3

Column End	Rebar A_{sv} /s mm^2/m	Design V_{u3} kN	Station Loc mm	Controlling Combo
Top	443.37	4.8215	3100	1.5(DL+LL)
Bottom	443.37	4.8215	0	1.5(DL+LL)

1. Design and Analysis of Single-Store Building

The single-store L shape building was designed and analysed by ETAB software as per Indian standard code IS:456-2000. The size of building (11mX8mX3.5m) in which the following parameters were considered for the purpose of design such as Beam size-300x400mm; Beam longitudinal length-5m, 6m; Beam lateral length- 4m, 4mm; Beam area-1200 cm^2, grade of concrete-M20, Ec (MPa)-22360.68, grade of steel HYSD Grade 415(Fe415)-Uniaxial type, Slab-120mm thickness; Element type-Shell thin; Grade of concrete-M20-Isotropic type, Live load-0.75KN/m^2, Dead load-2KN/m; Column Element details-Column size-400X400mm; Column length-3.5m;Column area-1800 cm^2 .

The geometry (Figure 5) was created as per given dimension such as columns, beams, and slabs, assign material properties and support condition, assign dead/live load value in turn design and analysed the building system as per stipulated code condition. Joint assignment indicates details about story level, diaphragm, restraints, label, and unique name as represented in Table 24.

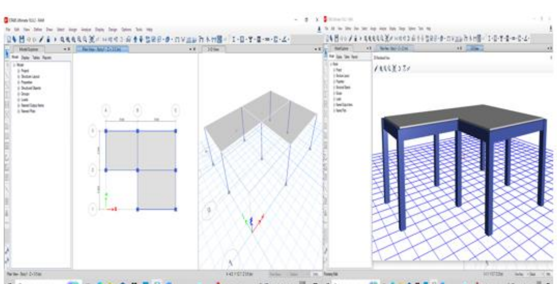

Figure 5 Plan and 3D view/3D render view of Single storey building

Table 24 Joint Assignments

Story	Label	Unique	Diaphragm	Restraints	Story	Label	Unique name	Diaphragm	Restraints
Story1	2	2	From Area		Base	2	11	From Area	UX;UY;UZ
Story1	3	3	From Area		Base	3	12	From Area	UX;UY;UZ
Story1	4	4	From Area		Base	4	13	From Area	UX;UY;UZ
Story1	5	5	From Area		Base	5	14	From Area	UX;UY;UZ
Story1	6	6	From Area		Base	6	15	From Area	UX;UY;UZ
Story1	7	7	From Area		Base	7	16	From Area	UX;UY;UZ
Story1	8	8	From Area		Base	8	17	From Area	UX;UY;UZ
Story1	9	9	From Area		Base	9	18	From Area	UX;UY;UZ

It is defined as the horizontal reactions at the supports. It is represented in terms of 'kN'. Base reaction was observed to be 523.88 KN and 51 KN in case of dead load and live load. For in case of combined loading case (dead load + live load), the base reaction was observed to be 882.30 KN (Table 25).

Table 25 Base Reactions

Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m	X m	Y m	Z m
Dead	LinStatic			0	0	523.8677	2388.196	-3248.975	0	0	0	0
Live	LinStatic			0	0	51	234	-325.5	0	0	0	0
Modal	LinModEigen	Mode	1	2.3275	-0.0208	0	0.0727	8.1464	-10.5931	0	0	0
Modal	LinModEigen	Mode	2	-0.018	-2.6115	0	9.1401	-0.0629	-17.636	0	0	0
Modal	LinModEigen	Mode	3	0.066	0.4142	0	-1.4495	0.231	-13.5741	0	0	0
Modal	LinModEigen	Mode	4	0.1011	0.5173	0	-1.8106	0.3539	1.4066	0	0	0
Modal	LinModEigen	Mode	5	0.014	0.419	0	-1.4666	0.0489	2.3141	0	0	0
Modal	LinModEigen	Mode	6	0.5375	-0.2119	0	0.7418	1.8812	-1.7536	0	0	0
Modal	LinModEigen	Mode	7	0.0601	-0.0729	0	0.2553	0.2103	0.9455	0	0	0
Modal	LinModEigen	Mode	8	0.0578	0.5219	0	-1.8265	0.2023	2.6991	0	0	0
Modal	LinModEigen	Mode	9	-0.2509	0.2865	0	-1.0028	-0.8781	5.5254	0	0	0
Modal	LinModEigen	Mode	10	0.0871	-0.1522	0	0.5327	0.3048	-2.7275	0	0	0
Modal	LinModEigen	Mode	11	-0.0651	-0.0587	0	0.2055	-0.2277	1.0799	0	0	0
Modal	LinModEigen	Mode	12	0.1147	-0.0727	0	0.2544	0.4016	1.0783	0	0	0
1.5(DL+LL)	Combination			0	0	862.3016	3933.2943	-5361.7134	0	0	0	0

Drift is defined as the ratio of displacement of two consecutive floors to height. The maximum permissible drift is limited to 0.004 times the height of the story. It is a very important term used for research purposes in an earthquake engineering. The story drift in any storey due to maximum specified design lateral force, with a partial load factor of 1. The variation of story drifts was indicated in dead load and live load case as well as in combined load case (dead load +live load) which is represented in Table 26.

Table 26 Story Drifts

Story	Output Case	Case Type	Step Type	Step Number	Direction	Drift	Label	X m	Y m	Z m
Story1	Dead	LinStatic			X	6.4E-05	9	11	8	3.5
Story1	Dead	LinStatic			Y	1.5E-05	3	0	8	3.5
Story1	Live	LinStatic			X	1.3E-05	9	11	8	3.5
Story1	Live	LinStatic			Y	3E-06	3	0	8	3.5
Story1	Modal	LinModEigen	Mode	1	X	4.6E-05	7	11	0	3.5
Story1	Modal	LinModEigen	Mode	2	Y	5E-05	8	11	4	3.5
Story1	Modal	LinModEigen	Mode	3	X	4.5E-05	4	5	0	3.5
Story1	Modal	LinModEigen	Mode	3	Y	6.8E-05	2	0	4	3.5
Story1	Modal	LinModEigen	Mode	4	Y	7.5E-05	2	0	4	3.5
Story1	Modal	LinModEigen	Mode	5	X	8.9E-05	3	0	8	3.5

Story	Output Case	Case Type	Step Type	Step Number	Direction	Drift	Label	X m	Y m	Z m
Story1	Modal	LinModEigen	Mode	5	Y	7E-05	9	11	8	3.5
Story1	Modal	LinModEigen	Mode	6	X	7.3E-05	8	11	4	3.5
Story1	Modal	LinModEigen	Mode	6	Y	7.7E-05	7	11	0	3.5
Story1	Modal	LinModEigen	Mode	7	X	0.000104	9	11	8	3.5
Story1	Modal	LinModEigen	Mode	7	Y	5.5E-05	7	11	0	3.5
Story1	Modal	LinModEigen	Mode	8	X	9.8E-05	7	11	0	3.5
Story1	Modal	LinModEigen	Mode	8	Y	9.9E-05	4	5	0	3.5
Story1	Modal	LinModEigen	Mode	9	X	0.000102	3	0	8	3.5
Story1	Modal	LinModEigen	Mode	9	Y	4.5E-05	7	11	0	3.5
Story1	Modal	LinModEigen	Mode	10	X	8.7E-05	2	0	4	3.5
Story1	Modal	LinModEigen	Mode	10	Y	6.9E-05	9	11	8	3.5
Story1	Modal	LinModEigen	Mode	11	X	8.7E-05	8	11	4	3.5
Story1	Modal	LinModEigen	Mode	11	Y	7.1E-05	7	11	0	3.5
Story1	Modal	LinModEigen	Mode	12	X	8.8E-05	6	5	8	3.5
Story1	Modal	LinModEigen	Mode	12	Y	6.2E-05	4	5	0	3.5
Story1	1.5(DL+LL)	Combination			X	0.000116	9	11	8	3.5
Story1	1.5(DL+LL)	Combination			Y	2.8E-05	3	0	8	3.5

The storey forces graph shows the lateral force that is applied at each floor level, but does not include any lateral forces that are applied to columns or walls between the floors. For a seismic analysis the storey forces come from the lateral acceleration of the masses in each floor. In ETABS, go to Display > Show tables > Select story drifts and story forces tables > and see if there is story drift or story forces present in there. or else there is some connectivity issue between members in the model and perform the check model function for this issue (Figure 27). Story forces varies from 411.90 KN to 523.86 KN for location at top and bottom in case of dead load linear static case. Also, its observed that, story forces were not varied for in case of live load linear static for location at top and bottom (51KN). For in case of load combinations (dead load+live load), story forces were observed to be 694.3512 KN/862.3016KN at top and bottom location in linear static case.

Table 27 Story Forces

Story	Output Case	Case Type	Step Type	Step Number	Location	P kN	VX kN	VY kN	T kN-m	MX kN-m	MY kN-m
Story1	Dead	LinStatic			Top	411.9008	0	0	0	1884.345	-2577.174
Story1	Dead	LinStatic			Bottom	523.8677	0	0	0	2388.1962	-3248.9756
Story1	Live	LinStatic			Top	51	0	0	0	234	-325.5
Story1	Live	LinStatic			Bottom	51	0	0	0	234	-325.5
Story1	Modal	LinModEigen	Mode	1	Top	0	2.3275	-0.0208	-10.5931	0	0
Story1	Modal	LinModEigen	Mode	1	Bottom	0	2.3275	-0.0208	-10.5931	0.0727	8.1464
Story1	Modal	LinModEigen	Mode	2	Top	0	-0.018	-2.6115	-17.636	0	0
Story1	Modal	LinModEigen	Mode	2	Bottom	0	-0.018	-2.6115	-17.636	9.1401	-0.0629

Story	Output Case	Case Type	Step Type	Step Number	Location	P kN	VX kN	VY kN	T kN-m	MX kN-m	MY kN-m
Story1	Modal	LinModEigen	Mode	3	Top	0	0.0666	0.4142	-13.5741	0	0
Story1	Modal	LinModEigen	Mode	3	Bottom	0	0.0666	0.4142	-13.5741	-1.4495	0.231
Story1	Modal	LinModEigen	Mode	4	Top	0	0.1011	0.5173	1.4066	0	0
Story1	Modal	LinModEigen	Mode	4	Bottom	0	0.1011	0.5173	1.4066	-1.8106	0.3539
Story1	Modal	LinModEigen	Mode	5	Top	0	0.014	0.419	2.3141	0	0
Story1	Modal	LinModEigen	Mode	5	Bottom	0	0.014	0.419	2.3141	-1.4666	0.0489
Story1	Modal	LinModEigen	Mode	6	Top	0	0.5375	-0.2119	-1.7536	0	0
Story1	Modal	LinModEigen	Mode	6	Bottom	0	0.5375	-0.2119	-1.7536	0.7418	1.8812
Story1	Modal	LinModEigen	Mode	7	Top	0	0.0601	-0.0729	0.9455	0	0
Story1	Modal	LinModEigen	Mode	7	Bottom	0	0.0601	-0.0729	0.9455	0.2553	0.2103
Story1	Modal	LinModEigen	Mode	8	Top	0	0.0578	0.5219	2.6991	0	0
Story1	Modal	LinModEigen	Mode	8	Bottom	0	0.0578	0.5219	2.6991	-1.8265	0.2023
Story1	Modal	LinModEigen	Mode	9	Top	0	-0.2509	0.2865	5.5254	0	0
Story1	Modal	LinModEigen	Mode	9	Bottom	0	-0.2509	0.2865	5.5254	-1.0028	-0.8781
Story1	Modal	LinModEigen	Mode	10	Top	0	0.0871	-0.1522	-2.7275	0	0
Story1	Modal	LinModEigen	Mode	10	Bottom	0	0.0871	-0.1522	-2.7275	0.5327	0.3048
Story1	Modal	LinModEigen	Mode	11	Top	0	-0.0651	-0.0587	1.0799	0	0
Story1	Modal	LinModEigen	Mode	11	Bottom	0	-0.0651	-0.0587	1.0799	0.2055	-0.2277
Story1	Modal	LinModEigen	Mode	12	Top	0	0.1147	-0.0727	1.0783	0	0
Story1	Modal	LinModEigen	Mode	12	Bottom	0	0.1147	-0.0727	1.0783	0.2544	0.4016
Story1	1.5(DL+LL)	Combination			Top	694.3512	0	0	0	3177.5175	-4354.0111
Story1	1.5(DL+LL)	Combination			Bottom	862.3016	0	0	0	3933.2943	-5361.7134

Joint reaction is an analysis for calculating resultant forces and moments at joint. Specifically, it calculates the joint forces and moments transferred between consecutive bodies as a result of all loads acting on the model (Table 28).

Table 28 Joint Reactions

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Base	2	11	Dead	LinStatic			3.1127	2.7985	45.9897	0	0	0
Base	2	11	Live	LinStatic			0.3643	0.4158	3.0078	0	0	0

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Base	2	11	Modal	LinModEigen	Mode	1	0.2618	-0.005	0.3102	0	0	0
Base	2	11	Modal	LinModEigen	Mode	2	-0.0145	-0.2621	-0.4548	0	0	0
Base	2	11	Modal	LinModEigen	Mode	3	-0.0318	0.4767	0.7643	0	0	0
Base	2	11	Modal	LinModEigen	Mode	4	-0.2986	0.521	0.571	0	0	0
Base	2	11	Modal	LinModEigen	Mode	5	0.0998	0.0216	0.211	0	0	0
Base	2	11	Modal	LinModEigen	Mode	6	0.299	-0.1328	0.0641	0	0	0
Base	2	11	Modal	LinModEigen	Mode	7	0.4906	0.0232	0.5065	0	0	0
Base	2	11	Modal	LinModEigen	Mode	8	0.0199	0.0102	0.0813	0	0	0
Base	2	11	Modal	LinModEigen	Mode	9	0.2661	0.1207	0.2615	0	0	0
Base	2	11	Modal	LinModEigen	Mode	10	0.4805	0.1204	0.736	0	0	0
Base	2	11	Modal	LinModEigen	Mode	11	-0.1771	-0.1124	-0.4207	0	0	0
Base	2	11	Modal	LinModEigen	Mode	12	0.0389	-0.0743	-0.3441	0	0	0
Base	2	11	1.5(DL+LL)	Combination			5.2155	4.8215	73.4962	0	0	0
Base	3	12	Dead	LinStatic			3.372	-2.6113	46.4837	0	0	0
Base	3	12	Live	LinStatic			0.447	-0.3692	3.2263	0	0	0

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Base	3	12	Modal	LinModEigen	Mode	1	0.2578	-0.0162	0.3414	0	0	0
Base	3	12	Modal	LinModEigen	Mode	2	0.0285	-0.2561	0.4687	0	0	0
Base	3	12	Modal	LinModEigen	Mode	3	0.2063	0.4707	-0.5476	0	0	0
Base	3	12	Modal	LinModEigen	Mode	4	0.1481	0.5241	-0.7445	0	0	0
Base	3	12	Modal	LinModEigen	Mode	5	0.4934	0.0551	0.445	0	0	0
Base	3	12	Modal	LinModEigen	Mode	6	0.1378	-0.1105	0.3878	0	0	0
Base	3	12	Modal	LinModEigen	Mode	7	-0.1011	0.0421	-0.0733	0	0	0
Base	3	12	Modal	LinModEigen	Mode	8	0.139	0.0416	0.0834	0	0	0
Base	3	12	Modal	LinModEigen	Mode	9	-0.5549	0.0453	-0.538	0	0	0
Base	3	12	Modal	LinModEigen	Mode	10	-0.2131	0.2949	-0.5346	0	0	0
Base	3	12	Modal	LinModEigen	Mode	11	0.127	-0.173	0.4026	0	0	0
Base	3	12	Modal	LinModEigen	Mode	12	-0.1601	-0.2291	0.3473	0	0	0
Base	3	12	1.5(DL+LL)	Combination			5.7284	-4.4708	74.565	0	0	0
Base	4	13	Dead	LinStatic			6.6344	2.1836	52.1433	0	0	0
Base	4	13	Live	LinStatic			0.9442	0.3133	3.8449	0	0	0
Base	4	13	Modal	Lin Mod	Mode	1	0.2767	0.0016	0.3021	0	0	0

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
				Eigen								
Base	4	13	Modal	LinModEigen	Mode	2	-0.0433	-0.2752	-0.454	0	0	0
Base	4	13	Modal	LinModEigen	Mode	3	-0.274	0.1171	-0.1339	0	0	0
Base	4	13	Modal	LinModEigen	Mode	4	0.309	-0.3232	-0.102	0	0	0
Base	4	13	Modal	LinModEigen	Mode	5	-0.3417	-0.0068	-0.3813	0	0	0
Base	4	13	Modal	LinModEigen	Mode	6	0.0674	-0.3739	-0.312	0	0	0
Base	4	13	Modal	LinModEigen	Mode	7	0.1175	-0.1759	-0.1208	0	0	0
Base	4	13	Modal	LinModEigen	Mode	8	-0.1773	0.5655	0.7947	0	0	0
Base	4	13	Modal	LinModEigen	Mode	9	-0.4005	-0.1928	-0.4335	0	0	0
Base	4	13	Modal	LinModEigen	Mode	10	0.1528	0.1863	0.1681	0	0	0
Base	4	13	Modal	LinModEigen	Mode	11	0.0007	-0.1599	-0.2189	0	0	0
Base	4	13	Modal	LinModEigen	Mode	12	0.2763	0.3734	0.5842	0	0	0
Base	4	13	1.5(DL+LL)	Combination			11.3679	3.7453	83.9822	0	0	0
Base	5	14	Dead	LinStatic			3.736	0.9922	116.0701	0	0	0
Base	5	14	Live	LinStatic			0.8809	0.3074	15.5218	0	0	0
Base	5	14	Modal	LinModEigen	Mode	1	0.3921	-0.009	-0.061	0	0	0

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Base	5	14	Modal	LinModEigen	Mode	2	-0.0029	-0.4103	-0.0356	0	0	0
Base	5	14	Modal	LinModEigen	Mode	3	-0.0389	0.1647	0.0358	0	0	0
Base	5	14	Modal	LinModEigen	Mode	4	-0.2184	-0.3538	0.4445	0	0	0
Base	5	14	Modal	LinModEigen	Mode	5	0.1111	-0.2126	-0.5135	0	0	0
Base	5	14	Modal	LinModEigen	Mode	6	-0.1134	-0.062	0.0301	0	0	0
Base	5	14	Modal	LinModEigen	Mode	7	0.15	0.0793	0.0886	0	0	0
Base	5	14	Modal	LinModEigen	Mode	8	0.0841	0.1653	-0.871	0	0	0
Base	5	14	Modal	LinModEigen	Mode	9	0.1123	-0.1944	0.0725	0	0	0
Base	5	14	Modal	LinModEigen	Mode	10	0.1459	-0.1247	-1.1372	0	0	0
Base	5	14	Modal	LinModEigen	Mode	11	-0.1539	0.0778	0.7593	0	0	0
Base	5	14	Modal	LinModEigen	Mode	12	-0.4423	0.0243	-0.9071	0	0	0
Base	5	14	1.5(DL+LL)	Combination			6.9254	1.9494	197.3878	0	0	0
Base	6	15	Dead	LinStatic			2.0158	-3.2694	81.1803	0	0	0
Base	6	15	Live	LinStatic			0.3386	-0.6776	8.4542	0	0	0
Base	6	15	Modal	LinModEigen	Mode	1	0.3845	-0.003	-0.0779	0	0	0

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Base	6	15	Modal	LinModEigen	Mode	2	0.0324	-0.2945	0.4538	0	0	0
Base	6	15	Modal	LinModEigen	Mode	3	0.3088	0.1244	-0.2607	0	0	0
Base	6	15	Modal	LinModEigen	Mode	4	0.0082	-0.195	0.0345	0	0	0
Base	6	15	Modal	LinModEigen	Mode	5	0.1971	-0.289	-0.2995	0	0	0
Base	6	15	Modal	LinModEigen	Mode	6	0.224	0.1827	-0.233	0	0	0
Base	6	15	Modal	LinModEigen	Mode	7	-0.1511	0.2862	-0.7269	0	0	0
Base	6	15	Modal	LinModEigen	Mode	8	-0.0612	-0.0759	-0.1917	0	0	0
Base	6	15	Modal	LinModEigen	Mode	9	0.0294	-0.1362	0.7217	0	0	0
Base	6	15	Modal	LinModEigen	Mode	10	-0.2748	-0.432	0.6505	0	0	0
Base	6	15	Modal	LinModEigen	Mode	11	0.1937	0.2264	-0.5451	0	0	0
Base	6	15	Modal	LinModEigen	Mode	12	0.5535	-0.2697	0.3841	0	0	0
Base	6	15	1.5(DL+LL)	Combination			3.5316	-5.9205	134.4517	0	0	0
Base	7	16	Dead	LinStatic			-6.2247	2.2462	51.9383	0	0	0
Base	7	16	Live	LinStatic			-0.8474	0.3513	3.909	0	0	0
Base	7	16	Modal	LinModEigen	Mode	1	0.2627	-0.0005	-0.2956	0	0	0

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Base	7	16	Modal	LinModEigen	Mode	2	-0.0238	-0.3208	-0.4483	0	0	0
Base	7	16	Modal	LinModEigen	Mode	3	-0.2678	-0.2725	-0.1026	0	0	0
Base	7	16	Modal	LinModEigen	Mode	4	0.3073	0.1437	-0.1479	0	0	0
Base	7	16	Modal	LinModEigen	Mode	5	-0.3079	0.1068	0.5081	0	0	0
Base	7	16	Modal	LinModEigen	Mode	6	0.1528	0.4651	0.43	0	0	0
Base	7	16	Modal	LinModEigen	Mode	7	0.0728	-0.3324	-0.5337	0	0	0
Base	7	16	Modal	LinModEigen	Mode	8	0.4144	0.2167	0.1459	0	0	0
Base	7	16	Modal	LinModEigen	Mode	9	0.0106	0.2607	0.4813	0	0	0
Base	7	16	Modal	LinModEigen	Mode	10	-0.2719	0.1824	0.3484	0	0	0
Base	7	16	Modal	LinModEigen	Mode	11	-0.2418	0.4298	0.6005	0	0	0
Base	7	16	Modal	LinModEigen	Mode	12	0.0416	-0.0767	-0.228	0	0	0
Base	7	16	1.5(DL+LL)	Combination			-10.6082	3.8962	83.7711	0	0	0
Base	8	17	Dead	LinStatic			-7.2938	-0.0263	80.4634	0	0	0
Base	8	17	Live	LinStatic			-1.3959	0.0127	9.4626	0	0	0
Base	8	17	Modal	LinModEigen	Mode	1	0.2574	0.0047	-0.2804	0	0	0

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Base	8	17	Modal	LinModEigen	Mode	2	-0.0067	-0.471	0.01	0	0	0
Base	8	17	Modal	LinModEigen	Mode	3	-0.0317	-0.3944	0.0353	0	0	0
Base	8	17	Modal	LinModEigen	Mode	4	-0.0184	0.1381	-0.0629	0	0	0
Base	8	17	Modal	LinModEigen	Mode	5	-0.0096	0.3147	0.4158	0	0	0
Base	8	17	Modal	LinModEigen	Mode	6	-0.4553	0.0983	-0.5156	0	0	0
Base	8	17	Modal	LinModEigen	Mode	7	-0.0004	-0.1367	0.65	0	0	0
Base	8	17	Modal	LinModEigen	Mode	8	-0.0982	-0.0988	-0.6346	0	0	0
Base	8	17	Modal	LinModEigen	Mode	9	0.1644	0.1694	-0.1789	0	0	0
Base	8	17	Modal	LinModEigen	Mode	10	0.1091	0.0111	-0.7651	0	0	0
Base	8	17	Modal	LinModEigen	Mode	11	0.546	-0.0194	-1.1532	0	0	0
Base	8	17	Modal	LinModEigen	Mode	12	-0.1757	-0.0106	0.4752	0	0	0
Base	8	17	1.5(DL+LL)	Combination			-13.0345	-0.0205	134.889	0	0	0
Base	9	18	Dead	LinStatic			-5.3524	-2.3134	49.5989	0	0	0
Base	9	18	Live	LinStatic			-0.7317	-0.3537	3.5735	0	0	0
Base	9	18	Modal	LinModEigen	Mode	1	0.2346	0.0066	-0.2388	0	0	0
Base	9	18	Modal	LinModEigen	Mode	2	0.0124	-0.3215	0.4603	0	0	0
Base	9	18	Modal	LinModEigen	Mode	3	0.1951	-0.2724	0.2094	0	0	0
Base	9	18	Modal	LinModEigen	Mode	4	-0.1361	0.0625	0.0073	0	0	0
Base	9	18	Modal	LinModEigen	Mode	5	-0.2284	0.4293	-0.3854	0	0	0
Base	9	18	Modal	LinModEigen	Mode	6	0.2252	-0.2789	0.1486	0	0	0
Base	9	18	Modal	LinModEigen	Mode	7	-0.5182	0.1413	0.2096	0	0	0
Base	9	18	Modal	LinModEigen	Mode	8	-0.2628	-0.3028	0.5922	0	0	0
Base	9	18	Modal	LinModEigen	Mode	9	0.1218	0.2139	-0.3865	0	0	0
Base	9	18	Modal	LinModEigen	Mode	10	-0.0415	-0.3906	0.5337	0	0	0
Base	9	18	Modal	LinModEigen	Mode	11	-0.3598	-0.3281	0.5755	0	0	0
Base	9	18	Modal	LinModEigen	Mode	12	-0.0174	0.1901	-0.3115	0	0	0
Base	9	18	1.5(DL+LL)	Combination			-9.1262	-4.0007	79.7586	0	0	0

IV. DISCUSSION OF RESULTS

The present research attempted to design and analyses a single story-building as per Indian standard code IS:456-2000 by ETAB software. In IS 456:2000 Clause 26, a requirement related to reinforcement used in RCC is given. In beams, slabs maximum percentage of steel is 4% of the gross area. In the column, the maximum % of steel is 4%. It is defined (story drift) as the ratio of displacement of two consecutive floors to the height of that floor. It is a very important term used for research purposes in earthquake engineering. The story drifts in any story due to the minimum specified design lateral force, with a partial load factor of 1.0, which shall not exceed 0.004 times the story height. It is the total displacement of its story concerning ground and there is a maximum permissible limit prescribed in IS codes for buildings. The deflection at any point on the axis of the beam is the distance between its position before and after loading. Shear force is the force applied perpendicular to a surface, in opposition to an offset force acting in the opposite direction. This results in a shear strain. In simple terms, one part of the surface is pushed in one direction, while another part of the surface is pushed in the opposite direction. The bending moment is a measure of the bending effect that can occur when an external force or moment is applied to a structural element. This concept is important in structural engineering as it can be used to calculate where, and how much bending may occur when forces are applied. The 3D view of longitudinal reinforcement (Figure 6) confirmed that the flexural longitudinal reinforcement was observed to be 291 and 184 mm² which is required rebar at the top + ve axis and bottom -ve axis of the longitudinal beam. It's also possible to interpret that shear (Figure 7) and torsion reinforcement with a magnitude of 332.53 mm² and 289.16 mm² respectively were observed from design and analysis.

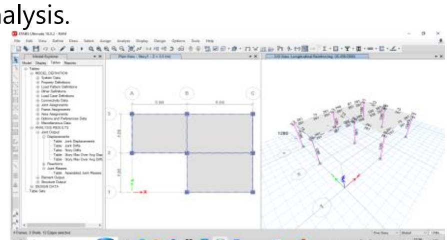

Figure 6 3D view of Longitudinal reinforcement

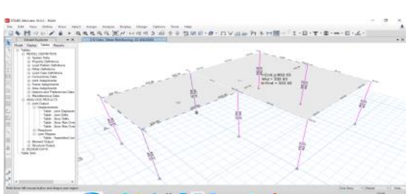

Figure 7 3D view of Shear reinforcement

As per IS 456:2000 in slabs per Clause 26.5. 2.1 Min reinforcement shall be 0.15% of the total cross-sectional area for mild steel bars and 0.12% of the total cross-sectional area for HYSD (Fe415) bars. Maximum tension and compression reinforcement for the beam is 4% of the total cross-sectional area of the beam. According to Clause 26.5. 3.1 of IS 456: 2000, the maximum longitudinal steel reinforcement for the column is 6 % of the gross column area. For very large columns, the minimum longitudinal steel reinforcement for the column is 0.8 % of the actual column area. It is observed in the present research work that, the percentage of reinforcement value obtained from design and analysis was within the stipulated limits code value (Figure 8). When drawing in ETABS the default is to have the 1-axis horizontal and the 2-axis vertical. This means that the flexural modifier for EI should be applied to f22 for wall piers and to f11 for spandrels. If you apply the modifier to both f11 and f22 it hardly affects the results. F11: Direct force per unit length acting at the mid-surface of the element on the positive and negative 1 face in the 1-axis direction. F22: Direct force per unit length acting at the mid-surface of the element on the positive and negative 2 faces in the 2-axis direction (Figure 9). Shear and moment diagrams are graphs that show the internal shear and bending moment plotted along the length of the beam. They allow us to see where the maximum loads occur so that we can optimize the design to prevent failures and reduce the overall weight and cost of the structure. The profile of bending moment variation (3D view of the moment 3-3) was indicated in (Figure 10) with combined dead load and live load.

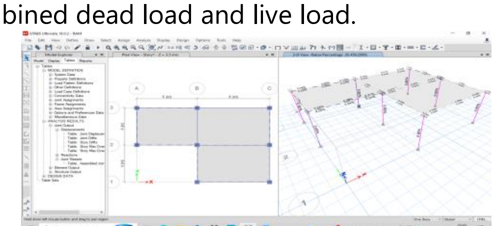

Figure 8 3D view of Rebar percentage

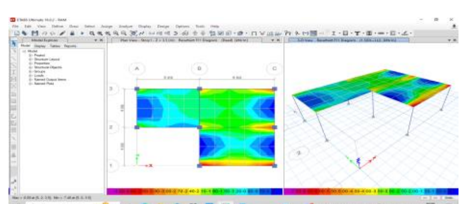

Figure 9 3D view of F11 diagram (1.5(DL+LL) KN/m

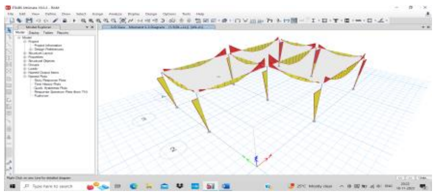

Figure 10 3D view of Moment 3-3 diagram

If movement (expansion and/or contraction) is restricted within a young concrete element, tensile stresses will develop which will lead to cracking. This restriction to movement is normally referred to as restraint. Restraints may be internal or external to the element (Figure 11).

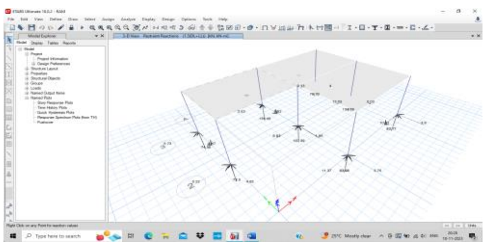

Figure 11 3D view of Restraint reactions

It's possible to interpret the story to displacement magnitude in any building structure for a given load condition, support condition, dynamic or static condition as per stipulated standard code. Story displacement is the deflection of a single story relative to the base or ground level of the structure. Intuitively, we can expect higher total displacement values as we move up the structure. Graph showing the story to displacement magnitude (dead load case) as represented in (Figure 12). Story displacement was maximum for in story1 and minimum (zero) at the base of the story. Story displacement means the displacement that occurred at each story level. In multi-storied buildings maximum storey displacement will be observed at the top stories. As the height increases the storey displacement will have maximum value.

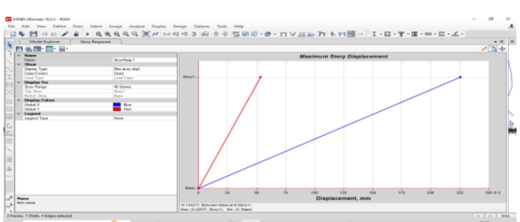

Figure 12 Story versus Displacement

Interaction Diagram in a column is a graph that shows a plot for the axial load P (KN) that a column could carry versus its moment capacity, M (KN-m). This diagram is very useful in analysing the strength of a column which varies according to its loads and moments. The interaction surface for section column (Figure 13) indicates Design code data (exclude material strength reduction), Axial load (-ve axial load, +ve axial load), and Moment (M2-ve/+ve, M3-ve/+ve). The P-M interaction curve indicates the capacity for P and M that reinforced concrete can resist. Vertical members that are part of a building frame are subjected to combined axial loads and bending moments. These forces develop due to external loads, such as dead, live, and wind loads.

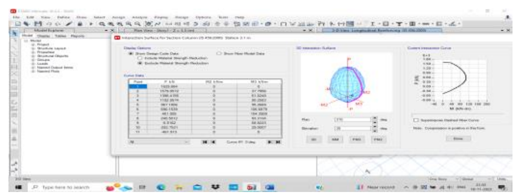

Figure 13 Interaction surface for section column

The interaction surface for the section column (Figure 14) indicates Design code data (including material strength reduction), Axial load (-ve axial load, +ve axial load), and Moment (M2-ve/+ve, M3-ve/+ve). P-M interaction curve indicates the capacity for P and M that reinforced concrete can resist in case of dead load and live load.

For the design of a column to be considered adequate (safe), the combination of action effects (M, P) must be less than the combination of design strengths (M, P) from the interaction curve. It's possible to represent the interaction surface for the section column in case of including material strength reduction and superimposed fiber curve as indicated in Figure 15.

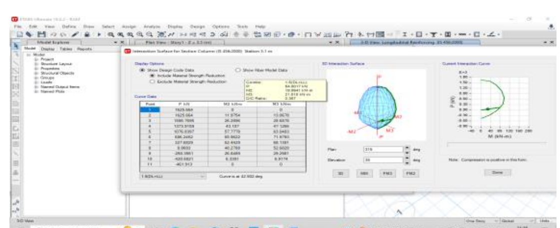

Figure 14 Interaction surface section column

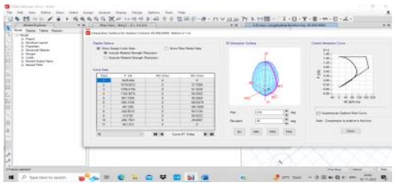

Figure 15 Interaction surface for section column

Story displacement is the deflection of a single story relative to the base or ground level of the structure. Intuitively, we can expect higher total displacement values as we move up the structure. The importance of story drift is in the design of partitions/ curtain walls. As per Indian standard, Criteria for earthquake resistant design of structures, IS 1893(Part 1): 2016, the story drift in any story shall not exceed 0.004 times the story height. Lateral displacement is important when structures are subjected to lateral loads like earthquake and wind loads. Lateral displacement depends on the height of the structure and the slenderness of the structure because structures are more vulnerable as the height of the building increases by becoming more flexible to lateral loads. It's confirmed from (Figure 16) that, the magnitude of displacement (0.004044 mm) between base and story 1. Furthermore, it’s also observed that the maximum displacement at story 1 was 0.044089 mm and the minimum (0 mm) at the base in the case of live load respectively.

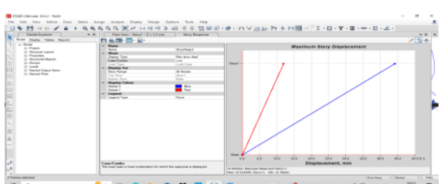

Figure 16 story versus Displacement

It's noted from (Figure 17) that, the magnitude of displacement (0.034928 mm) between base and story 1. Furthermore, it’s also observed that the maximum displacement at story 1 was 0.404489 mm and the minimum (0 mm) at the base in the case of a combination of live load and dead load respectively.

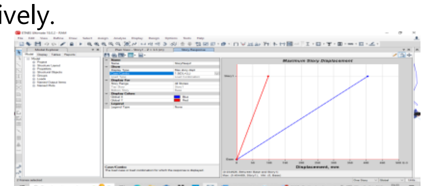

Figure 17 Story versus Displacement

V. CONCLUSION

- Thus, in the present research work, the design and analysis of a single-story building was carried out by using ETAB software and successfully verified as per IS456:2000.
- Calculation by ETAB software analysis gives results within the permissible limit according to IS code.
- Further the work is extended for a story building and found that the results matched.
- Usage of ETABS software minimizes the time required for analysis and design.
- It can easily add and remove the story of the building

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